PB-221 547

SHORE TERMINATION FOR OIL SPILL BOOMS

Archie C. Roberts

Edison Water Quality Research Laboratory

Prepared for:

Environmental Protection Agency

February 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

EPA-R2-73-114
FEBRUARY 1973

W73_11437

Environmental Protection Technology Series

PB 221 547

Shore Termination for Oil Spill Booms

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

23

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Monitoring, Environmental Protection Agency, have been grouped into five series. These five broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The five series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

1. Report No. 2. W 73-11437

SHORE TERMINATION FOR OIL SPILL BOOMS,

5. Report Date
6.
8. Performing Organization Report No.

Roberts, ~~Archie~~ C.

~~Alpine Geophysical Associates, Inc.~~
~~under contract to~~
New York City Fire Department, N.Y.

EPA Project 15080 FVP

13. Type of Report and Period Covered

~~12. Sponsoring Organization~~ ~~Environmental Protection Agency, W.Q.O.~~

Environmental Protection Agency, Technology Series report ~~number~~, EPA-R2-73-114, February 1973. 21p, 3 fig, 1 ref

One of the most common sources of failure in the application of floating oil booms to contain an oil spill is leakage between the end of the boom and the adjacent shoreline, deck or bulkhead. Booms cannot be fastened solidly to the shore since they must rise and fall with the changes in height due to tides and waves. The use of counter-currents generated by a fire stream or prop wash is attractive, although it ties up a boat often needed for other tasks. Furthermore, the shallow draft of a small boat allows oil to escape beneath the boat unless the boat is overlapped by the boom. Securing boom to the boat while avoiding the fouling of the boat's propeller then becomes operational concerns.

~~This report describes~~ is described a simple structure for mounting a small outboard motor to "seal" the gap. This boom terminator can be constructed on-scene with tools and materials generally available around the waterfront by relatively unskilled personnel. (EPA)

~~This report was submitted in partial fulfillment of Project 15080 FVP, under the partial sponsorship of the Water Quality Office, Environmental Protection Agency.~~

17a. Descriptors: *Oil Spills, *Harbors, *Hydrodynamics, Riprap, Water pollution control, Pollution abatement, Oil pollution

17b. Identifiers: *Containment Boom Terminator, *Oil Seal, *Boom Terminal Gap, Construction Details, *Booms

73-114

Copy available from GPO Sup Doc as EP 1.23/2:, $0.50; microfiche from NTIS as PB 221 347, $0.95.

~~050~~ 056

19. Security Class. (Report)
20. Security Class. (Page)
21. No. of Pages 21
22. Price

Send To:
WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C. 20240

Archie C. Roberts | Alpine Geophysical Assoc. Inc. for NYFD

EPA-R2-73-114
February 1973

SHORE TERMINATION FOR OIL SPILL BOOMS

by

Archie C. Roberts

Project 15080 FVP

Project Officer:

Frank J. Freestone
Edison Water Quality Research Laboratories, NERC
Edison, New Jersey 08817

Prepared for
OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price 50 cents domestic postpaid or 35 cents GPO Bookstore

EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

SHORE TERMINATION FOR OIL SPILL BOOMS

One of the most common sources of failure in the application of floating oil booms to contain an oil spill is leakage between the end of the boom and the adjacent shoreline, deck or bulkhead. Booms cannot be fastened solidly to the shore since they must rise and fall with the changes in height due to tides and waves. The use of counter-currents generated by a fire stream or prop wash is attractive, although it ties up a boat often needed for other tasks. Furthermore, the shallow draft of a small boat allows oil to escape beneath the boat unless the boat is overlapped by the boom. Securing boom to the boat while avoiding the fouling of the boat's propeller then become operational concerns.

This report describes a simple structure for mounting a small outboard motor to "seal" the gap. This boom terminator can be constructed on-scene with tools and materials generally available around the waterfront by relatively unskilled personnel.

This report was submitted in partial fulfillment of Project 15080 FVP, under the partial sponsorship of the Water Quality Office, Environmental Protection Agency.

CONTENTS

Section		Page
I	Conclusions	1
II	Introduction	3
III	Background Study	5
IV	Preliminary Design	7
V	Final Design	11
VI	Application	15
VII	Acknowledgments	19
VIII	References	21

Preceding page blank

FIGURES

Number		Page
1.	Boom Terminator Construction Plan	13
2.	Boom Terminator Applications - a. Diversion	16
	Boom Terminator Applications - b. Collection	16
3.	Terminator in Use	18

SECTION I

CONCLUSIONS

The use of prop wash to produce currents for herding and diverting oil slicks is common practice. Such currents are useful in preventing the spread of oil around the ends of boom where it is either impossible or difficult to make an oil tight connection to the shore. The boom terminator described above is one method of providing such a current which makes it unnecessary to tie up a boat for this purpose. Except for the need of occasionally refueling the engine, it also works unattended. The construction materials should be readily available, and the only expensive item is the outboard motor which, in this type of emergency, could probably be borrowed for the spill duration. The construction of the unit is well within the capabilities of the average do-it-yourself carpenter. Because of the ease of construction, it is unnecessary to maintain assembled terminators for an emergency. It is only necessary to become familiar with the design and to stock the materials.

SECTION II

INTRODUCTION

A total boom system for controlling the spread and preventing the escape of oil is only as good as its weakest component. If a containment boom is used under sea conditions within its design specification, the weak points often prove to be the boom ends and ways must be found to seal the terminal gaps to maintain the integrity of the total system. One problem normally encountered is making an effective seal between the boom end and the shore. The seal should have a good probability of being effective under the majority of conditions encountered in those areas for which the equipment is designed.

At certain stages of its research program on oil spill control, the Marine Division of the Fire Department of the City of New York was faced with the problem of providing an effective seal between the boom used for test purposes and a bulkhead. The problem was easily solved by using water streams from the fireboat to provide a counter-current offsetting the normal water flow through the boom/bulkhead gap. It was recognized that this solution to the problem was not universally applicablicable, but the principle of blocking the normal flow through the gap with a counter-current was considered to be a reasonable approach to the problem, and this path was pursued in the subsequent investigation and design. The end product of the investigation is a design for a dynamic boom terminator which can be used in most situations where it becomes necessary to close off oil leaks around the ends of boom.

Preceding page blank

SECTION III

BACKGROUND STUDY

In most harbors subject to oil spills, the shoreline characteristics can vary from smooth vertical bulkheads to rough sloping riprap, and each type presents its individual problems for boom termination. The immediate shoreline of most harbors is found to be a result of land fill and dock building activity, and the chances of finding a smooth surface to provide a basis for a direct mechanical seal between boom and shore are rare. The options open are to fair out the surface to allow for a direct oil tight connection, or to go to some type of dynamic device which does not require a tight connection. One problem involved with riprap shorelines and the general run of land fill areas is that irregularities and voids are difficult to smooth out or fill. Often vertical bulkheads are faced with timbers to protect the concrete or stone and therefore do not provide a smooth profile.

In addition to the problems presented by the character of the shoreline, the sea itself makes its contribution. Values of current, tide and wave must be considered in determining the design criteria, and the limiting values of each imposes restraints on the terminator design. In this case, the values used were those likely to be encountered in New York Harbor and could be considered as fairly representative of most ports in the United States.

Although currents in areas of New York Harbor often reach values in excess of 5 knots, the terminator need only be as effective as the boom itself, and analyses of fixed boom have shown that they will only contain oil at currents of 0.7 knots[1] normal to their direction. The design, therefore, was based on this lower figure. The design criteria for tidal range and wave height were taken as 6 feet and 2 feet, respectively.

Other types of boom termination were considered in addition to the use of water streams:

1. Sliding mechanical oil tight seals for vertical bulkheads
2. Bubble barriers

The first type has limited use. Its primary application would be for permanent oil terminal installations where an optimum design can be made to fit the particular conditions. The advantage of a well-engineered installation of this type is that it is completely passive

Preceding page blank

and requires no power input. It was not considered applicable to a situation where the shore/boom gap must be sealed off quickly for various types of shore profiles. Bubble barriers are much more universal and as a first order approximation their effectiveness is not seriously modified by waves or tidal changes. Research data indicates, however, that bubble barriers are only about one-half as effective as solid barriers when trying to hold back oil against a current. (See Reference [1]). Based on this background information, it was decided to concentrate on designing a terminator which could create a counter-current of sufficient velocity to counteract the normal current.

SECTION IV

PRELIMINARY DESIGN

During previous tests involving the herding of oil slicks for concentration and pick-up, two methods had been investigated: (1) Use of a boat's prop wash and (2) use of hose and fire monitor streams. These investigations indicated that, for herding, maneuvering the boat to utilize prop wash was not practical considering the water pumping capability of fireboats. For a boom terminator, however, the use of an outboard motor to produce a counter-current with its prop wash seemed attractive when compared with the alternative of creating a self-contained motor-water pump combination. The solution appeared to be in designing a stable platform which would hold an outboard motor and its gas tank, and orient it such that the prop wash was in the proper direction to counteract currents tending to flow through the boom/shore gap.

The initial tests were made using the fireboat's small workboat as a terminator. A section of oil spill boom was set out to form an U in the test basin with a gap between one boom end and a vertical bulkhead. A fireboat was moored further along the bulkhead and its monitor streams were used to set up a 1-knot current in the gap. The small boat, fitted with a 9-hp outboard, was placed in line with the boom, with the stern moored to the bulkhead, and the oil boom fastened and overlapping the forward end of the boat on the upstream side. The boom was set with the boat angled at 40° to the bulkhead so that its prop wash had a component opposing the current set up by the fireboat. The gap was adjusted to 10 feet by adjusting the securing line, and the motor started. Data processing cards were used as floaters to map the surface current flow. With the motor running at standard throttle, none of the cards penetrated the gap. The fan-shaped surface current set up by the prop wash bent the prevailing current flow lines so that those cards which would normally flow through the boom gap were deflected outward and were caught behind the boom.

Maintaining the 1-knot current, the boom gap was progressively opened to 15 and 20 feet. The data processing cards did not pass through with the 15-foot gap, but some did manage to penetrate when the opening was increased to 20 feet. Subsequent tests using a 5-hp motor showed that it would seal a 10-foot gap with an occasional card getting through at 15 feet. Based on these experiments and other size/weight considerations, it was decided to purchase a 6-hp engine for incorporation into the terminator design.

Some theoretical calculations based on the engine specifications were made to substantiate the experimental results. The propeller area was roughly 1/3 ft^2, its pitch 1/2 ft, and its speed 2400 rpm (40 rps).

Considering the propeller as a pump with perfect coupling, it should produce a water flow of 6-2/3 ft^3/sec at an output velocity of 20 ft/sec. This flow through a 1/3 ft^2 area can be considered ideally to have expanded into a 6-2/3 ft^2 area by the time the velocity had decreased to 1 ft/sec. This appears to be a reasonable area of surface current intercept. The next objective was to design an inexpensive, easily built terminator which would not require tying up the ship or its small boat, since they are usually needed for other work during an oil spill.

It should be noted, however, that if a spare small boat is available it could, with some adaptation, serve as a terminator. In an in-line configuration the small boat does not have enough draft to be an effective boom extension. The boom must, therefore, lap the boat and provisions must be made to fasten the boom and boat together while maintaining the boom integrity and assuring that the boom does not foul the propeller of the outboard motor. In waves there may be relative motion between boat and boom with subsequent chafing and boom damage.

In order to make a practical dynamic boom terminator, it must be built from materials readily available on the waterfront if it is to be of any use as an emergency piece of equipment. The structure for supporting the outboard and its fuel tank should also be made from inexpensive, readily attainable materials, and be suitable for construction by relatively inexperienced people, with a minimum of tools. The initial model of the terminator only partially met these specifications. The basic construction materials were plywood and a 55 gal. oil drum. The use of a 55 gal. drum for flotation at first glance appears to be a good choice since drums are easily available and can provide adequate buoyancy. The problems that arise are:

1. The stable flotation aspect is horizontal and it requires considerable ballast to make it float upright while supporting an outboard motor.

2. Since the drum becomes part of the boom it has to be ballasted down so that it has 2/3 of its 3 ft height submerged.

3. This type of buoy is a spar buoy, and is not surface-following for short period waves. The natural undamped period for such a buoy is

$$Tn = 2\pi (W/kg)^{1/2}$$

For a simple spar buoy

$$k = \frac{W}{d}$$

Where W = the weight of the buoy in pounds, and d = the static vertical displacement in water due to this weight in ft and g = accleration of gravity = 32.2 ft/sec^2.

$$Tn = 2\pi (d/g)^{1/2} = 1.11 \sqrt{d}$$

This calculation does not allow for end effects (added mass) on the drum which would tend to increase the period. The drum, therefore, will not follow short period waves.

4. The thin metal used in standard drums makes it impractical to weld attachments to it. These attachments must, therefore, be strapped on, making oil tight joints between the drum and the boom attachment plates difficult.

5. The outboard motor weight cannot be centered with respect to the buoyancy of the drum, and the ballast must be located so as to adjust the trim as well as the depth of flotation.

6. The overall design did not meet the criterion that it could easily be made by relatively inexperienced people. In addition to the wood work involved, the motor and ballast mounting brackets were fabricated from angle iron and required the services of a welder.

7. The finished terminator was heavy, weighing approximately 320 lbs without motor or fuel - the total rigged weight being about 380 lbs. This weight was too much for manhandling, and a small crane or davit was needed to launch it from the fireboat.

Although once in the water this terminator performed well, and alternative design was sought which would offset some of the disadvantages of the 55 gal. drum model and yet be able to support the outboard motor.

SECTION V

FINAL DESIGN

In order to provide a lightweight unit with a shorter natural period than the 55 gal. drum model, two criteria had to be met:

1. Considering the unit to be essentially a buoy, it must be of the surface-following rather than spar buoy type.

2. The stability must be provided by the buoyancy configuration and not by means of counterweights.

Both of these criteria are met by a raft. It is hard to tip over because of the large correcting moment produced as a result of heel, and it follows the surface because of the large areas crossing the air/water interface. In the formula for natural period for vertical motion

$$Tn = 2\pi (W/kg)^{1/2}$$

k (the equivalent spring coefficient which is a measure of the change in vertical displacement as a function of a change in weight) is large when the surface intercept area is large. By using low density flotation material, W (the weight) becomes small. The ratio W/k in the formula above, therefore, is decreased on both counts with a subsequent decrease in the natural period.

Two types of lightweight flotation were available - rigid foam and inflatable floats. Since rigid flotation is not universally available, and inflatables looked attractive from the storage point of view, the latter was chosen for buoyancy.

Selected was a heavy duty inner tube for truck tires. The outboard can be mounted with its shaft down through the center of the toroid formed by the large tube. The system is therefore balanced, and there is no need for large amounts of ballast to adjust the trim. Once this decision was made, the design was simply one of mechanically tying the boom, the flotation and outboard motor together. The resulting design is shown in Fig. 1. Two sheets of 1/2" marine or exterior plywood are connected in the shape of a V. A 2 x 12 timber is fastened across the V to serve as a motor mount. Each sheet of plywood has two holes cut in it, through which the tube can pass when it is inflated. In order to insert the tube, 1/2" slots extend vertically from the hole centers to the top of the plywood. The tube is slipped down through the slot while deflated, and then pumped up to fill the hole. The oil spill boom is sealed to the apex of the V and a split bridle is fastened at the open end for making the on-shore attachment.

Two versions of this terminator were made. The first was a rigid model

Preceding page blank

made to test out the design, while the second was a unit capable of being easily knocked down for stowage. Because the former is easier to construct and needs fewer purchased parts, it will be described in detail rather than the latter:

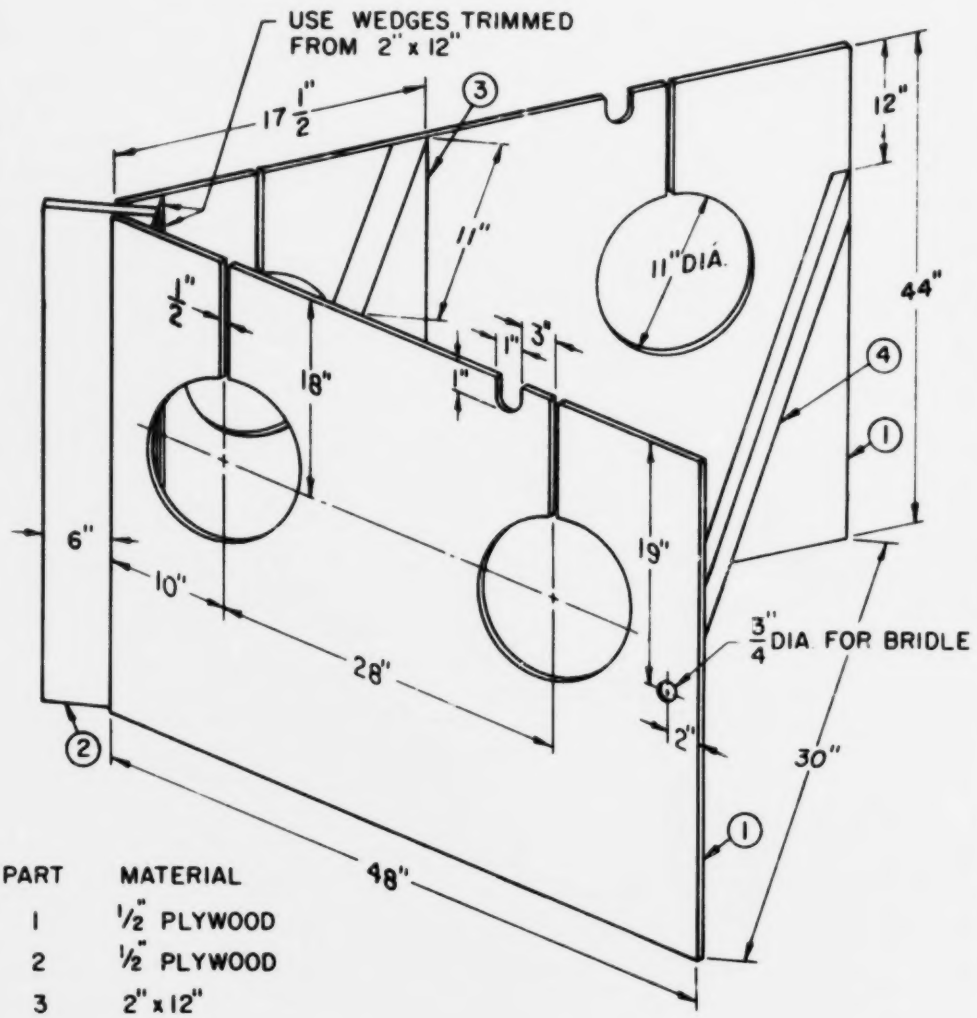
With reference to Fig. 1, the materials needed for construction are

1. 1 each 4' x 8' sheet of 1/2" marine or exterior plywood
2. 3 ft length of 2" x 12" (wood)
3. 30" length of 2" x 4" (wood)
4. 1 each 1000-20 truck tire tube
5. 1 each 1" dia by 36" hardwood dowel
6. 2 each 1" hose clamps
7. A supply of galvanized nails.

Although it is possible to build the unit with hand tools, use of a table saw and a saber saw would simplify the job.

The 1/2" plywood sheet will make the two sides plus the oil boom attachment strip. The edges of the 2" x 12" are ripped at 18° angles to fit as the motor mount bracket, and the two thin wedges cut off are used to fair the sides into the boom attachment strip. The 2" x 4" spreader at the open end of the V is also cut at an 18° angle. Dimensions for the cutouts in the side panels are shown in Fig. 1. The 1/2" slots which allow the deflated tube to be slipped down into position can be reclosed by tacking on 1/4" plywood battens. Be sure the sharp and ragged edges made by the saw while cutting the 11" hole are rounded off in order to prevent chafing of the tube. It should be noted that the actual shape of the hole formed by the intersection of the tube and plywood is a distorted ellipse. The tube will, however, conform to the circle and the layout work is thus simplified. The unit can be assembled with bolts, screws, or galvanzied nails - with nailing being the quickest and simplets method. A notch is cut in the top of each side panel to hold the 1" dowel, which in turn, is clamped to the gas tank handle with the hose clamps.

Two 3/4" holes are drilled in the plywood at the open end of the V for fastening a 2-part mooring bridle. These holes are positioned at the waterline for 1/2 tank fuel conditions. Thus, if the mooring line is fastened ashore at a height of mean tide, it produces the least possible vertical component tending to lift or submerge the unit as the tide changes. The plywood strip at the apex of the V can be drilled on site to match the end fittings of the particular boom being used. Make sure that the fastenings between the strip and the side panels are distributed proportionally to the in-line loads expected to be transmitted at each point of boom attachment. This applies particularly to points where wire rope or chain stress members are tied in.



PART	MATERIAL
1	½" PLYWOOD
2	½" PLYWOOD
3	2" x 12"
4	2" x 4"

FIGURE 1
BOOM TERMINATOR CONSTRUCTION PLAN

SECTION VI

APPLICATION

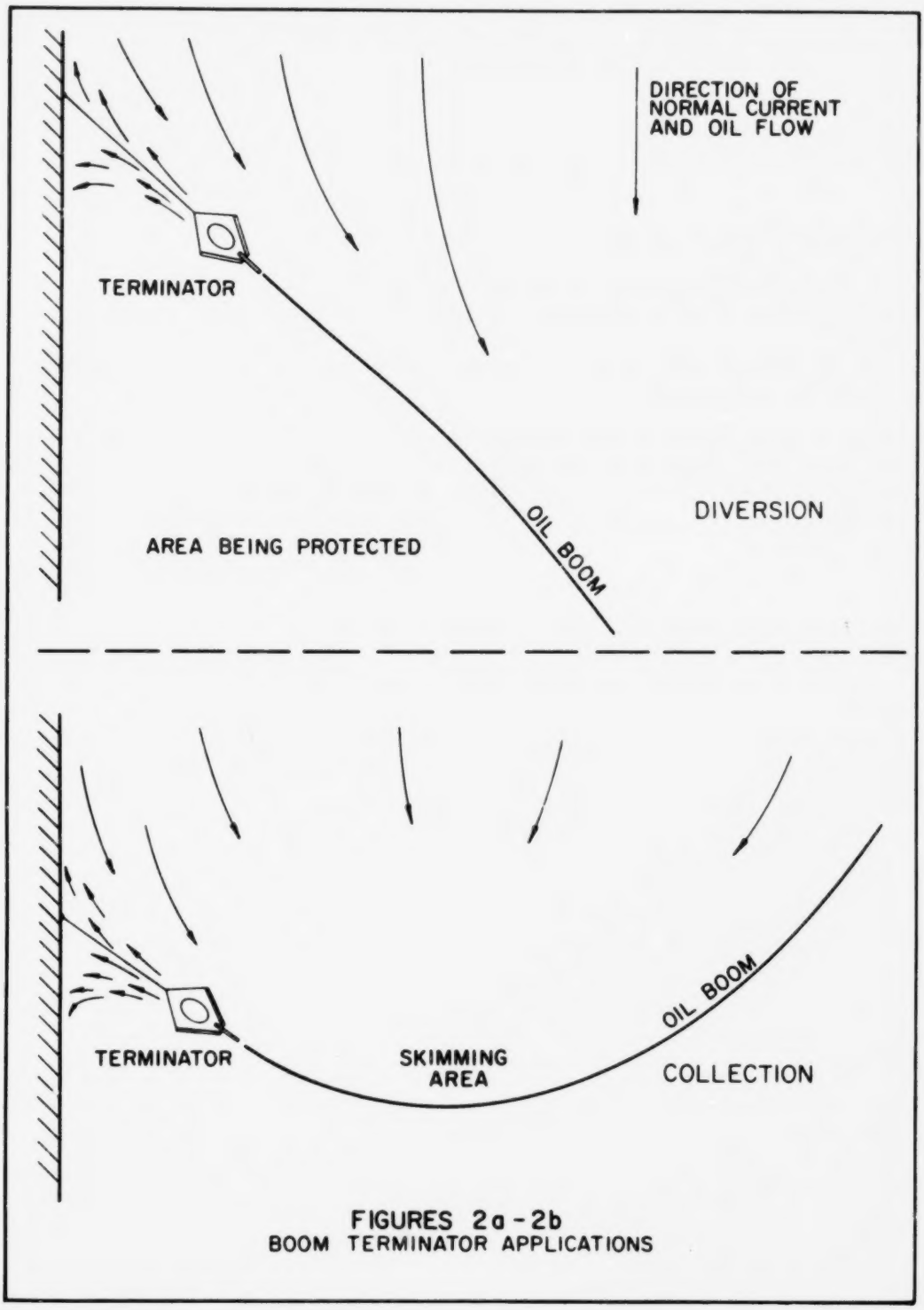
Oil spill booms are used in two manners:

1. To divert a moving oil slick and carry it away from an area which needs to be protected;

2. To prevent the spreading of oil and thicken it up for subsequent skimming operations.

Fig. 2 indicates how the terminator can be used under both conditions. In both configurations, the terminator is producing a current which is opposite the direction of oil flow, and acting as an extension of the boom.

Preceding page blank



FIGURES 2a - 2b
BOOM TERMINATOR APPLICATIONS

Figure 3

Boom Terminator in Use

SECTION VII

ACKNOWLEDGMENTS

The field testing necessary for the development of the dynamic Shore Termination for Oil Spill Booms, as described herein, was done by Alpine Geophysical Associates, Inc. with the full cooperation of the Officers and Members of the Marine Division of the New York City Fire Department.

The guidance of Mr. Howard Lamp'l, EPA Project Officer, and the cooperation of the City of New York and the U. S. Navy in providing the test basin at Wallabout Creek, Brooklyn, New York, is gratefully acknowledged.

Preceding page blank

SECTION VIII

REFERENCES

1. Milz, E. A., "An Evaluation of Oil Spill Control Equipment and Techniques", A.P.I.'s Division of Transportation Pipeline Conference, Dallas, 1970.

U. S. GOVERNMENT PRINTING OFFICE : 1973—514-153/220

Preceding page blank